Can geospatial technology aid in solving water access issues in the developing world? A review of Abuja, Nigeria

Usman, Sylvia; Meldrum, Anita

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CAN GEOSPATIAL TECHNOLOGY AID IN SOLVING WATER ACCESS ISSUES IN THE DEVELOPING WORLD? A REVIEW OF ABUJA, NIGERIA.

[1]SYLVIA USMAN, [2]ANITA MELDRUM
[1,2]Glasgow Caledonian University, G4 0BA, United Kingdom
Email: [1]sylvia.usman@gcu.ac.uk, [2]anita.meldrum@gcu.ac.uk

Abstract: In most developing countries especially in Africa, physical and anthropogenic activities, as well as population growth and climate change have caused pressures on basic infrastructures such as potable water supply. The rapid increase in migration and population growth threatens these infrastructures which reinforces the poverty cycle and undercuts economic growth. Abuja as the capital of Nigeria is one of the fastest growing cities in Africa and is faced with these challenges. However, limited statistical data about water and sanitation provides little information about the spatial distribution of water access in Abuja communities. Over the years, conventional methods of obtaining data have been complex and labour intensive. With the advent of Geospatial technology, spatial deliveries of numerical data and maps have supported the search for other relevant data, as well as improved data management. This paper aims to highlight the importance of adopting Geospatial technology for potable water access and management. Data was generated through household questionnaire survey tool administered to 200 residents of four (4) Peri-Urban areas of Abuja. The findings indicated that most residents rely on borehole water supply as their source of potable water supply. Overall, most people chose the quality of water over the cost of accessing water. In conclusion, the study discovered that despite water availability, access to a reliable source remained a challenge, especially as most residents relied on vendors for water supply. Hence, the need to embrace Geospatial technology is essential for its usefulness in national development and economic development.
Keywords: Geospatial Technology, GIS, Water Resource Management, Potable Water Supply, Water Access

1. INTRODUCTION

Water is a resource that supports human life and activities and so useful for a range of socio-economic activities such as: domestic, industrial, transport, food production, production of goods and services, health and hygiene, energy and transport [1]. However, due to the uneven distribution of fresh water temporally and spatially across the globe, water scarcity and shortage occur [2].

Water can be contaminated particularly due to inadequate water treatment and poor human sanitation practices [3]. Polluted water and improper sanitation pose threats to health and wellbeing due to water borne and water related diseases [4]. According to [5] about 842,000 people and 361, 000 children under the age of 5 years die annually of diarrhoea as a result of unsafe water, poor sanitation practices and poor hand hygiene. These deaths are avoidable with proper risk assessment and water management [5]. These limiting factors have substantially reduced development in Africa by constraining both industrial and human activities [5].

Developing countries in Sub-Saharan Africa lack adequate access to water supply and improved potable water; water access remains a huge challenge as population growth increases to [5]. These African countries, including Nigeria, are faced with both inadequate water and fresh water quality issues. Water access mostly in poor regions has been a menace, as people travel long distances in search of water [6]. For example, in Sub-Saharan Africa, about 742 million people who reside in rural areas lack access to safe water, compared to about 137 million people in urban areas [7]. Water shortage and inadequate water access have direct impact on human health and hygiene of which if not properly checked, could compromise human lives and cripple an economy [8]. In 2015, about 159 million people, directly collected drinking water from surface water sources, 58% lived in Sub-Saharan Africa (SSA) [5]. The implication of depending on such contaminated water sources is widespread as children under the age of five die daily from dehydration, malnutrition and diarrhoeal disease [5].

Global issues such as inadequate water supply, water access, health facilities and very recently climate change are topics for discussion in the global dialogue; especially for developing countries [9]. As the global population increases, so the demand for water and other basic resources increases [10]. Moreover, water conflicts have generated a growing competition and controversy between countries in the different regions; as water demand fails to meet water supply [11].

Poor water resource management and lack of strategies for effective water management contribute to water wastage and scarcity [12]. More than 1.2 billion of the world's population are faced with physical water scarcity conditions, which happen when most of the river flows; greater than 75 percent are withdrawn [13]. For example, water scarcity is rising in regions such as Southern Europe, Western Asia and Northern Africa; thus, limiting economic development [14]. More so, about 1.6 billion people in Southern Asia and Sub-Saharan Africa are faced with economic water scarcity due to limiting water access. *(See Fig 1)*.

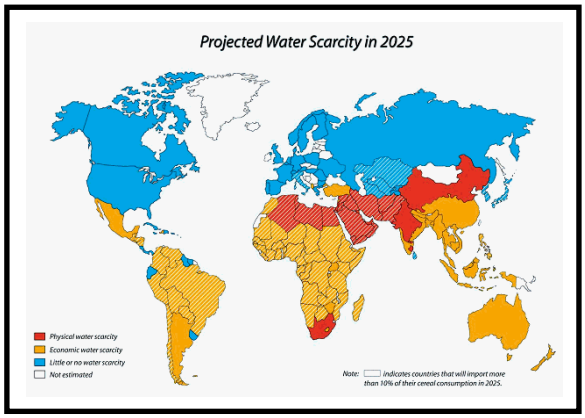

Fig. 1: Projected Water Scarcity Map in 2025. (Source: IWMI, 2000).

Efforts have been made to tackle water resource challenges at both international and national levels. For example, the United Nation's Millennium Development Goals (UN MDGs), which were aimed to eradicate hunger and poverty, combat infectious diseases and create partnerships for member countries through a framework for development, were put into place [15]. Some of the MDGs targets were met, including cutting the proportion of people without access to safe water provision by half [16]. However, five developing regions (Sub-Saharan Africa, Northern Africa, Asia, Oceania, and Caucasus) did not meet the set goal for drinking water; which was by 2015, to halve the proportion of people without sustainable safe drinking water access and basic sanitation [17]. Also, Nigeria failed to meet the MDGs due to bureaucracy in governance, poor resource management and monitoring systems and unrest in the Northern and Southern parts of the country.

1.1 Water Resource Management and Geographic Information Systems (GIS)

Water resource management involves the knowledge of basic spatial information such as water sources, land use, rainfall, and temperature and census data in order to understand hydrological processes. According to [18], the ideal way to manage spatial information is with a geographical database system such as GIS.

Geographic Information Systems (GIS)

A geographic Information system (GIS) is a computer based system that is used to collect, capture, analyse, store and manage spatial information [19]. GIS as a tool is useful for the display of geographical data as depicted on the Earth's surface [19]. Previous literature on water resource management and GIS shows that there exist gaps in knowledge about how to tackle water issues in Sub-Saharan Africa; especially in Nigeria.

Previous GIS Use in Water Resource Management.

GIS techniques have been employed in water resource management as high performance tools that play a critical role in decision support systems in other developed areas [20]. For example, recent studies show the capabilities of GIS applications in the water sector such as [21] emphasised the usefulness of GIS as a fundamental part of human lives and modern geography to facilitate the understanding of patterns/trends in phenomena. [22] used GIS to assess and monitor water quality of the Euphrates River in order to understand the spatial distribution of water pollutants. As a result of that study, a GIS model was developed to monitor and understand ways of managing the river. Furthermore, [23] reviewed the proliferation of shallow substandard private water wells in Imo State, Nigeria using GIS applications to create a GIS ground water model.

Remote sensed applications and GIS technologies have, over time, proven to be useful tools that have been applied in human daily activities through their services and have contributed significantly to the environmental field [21]. For instance in Africa, remote sensed and GIS datasets collected in recent times have aided greater understanding of African geography [21]. Geospatial technologies need to be applied in different sectors; particularly in the Nigerian water sector where proper water resource management information is minimal.

Most developing countries, can adopt the use of GIS technology as an assessment and application tool for water resource management to detect and map coastal area hazards, water hazards, for water quality detection, water pollution, flood mapping and to provide infrastructural information [24].

2. METHODOLOGY

2.1 Study Area

Abuja is the Federal Capital Territory of Nigeria and it's located within Nigeria between latitude 8º 25' and 9º 25'N and longitudes 6º 45' and 7º 45'E (See Fig 1.5). The city of Abuja covers an area of 7,315 sq / km (more than twice the area of Lagos state) [25], with an elevation of 2760ft above sea level [26]. It is to the north of the confluence of River Niger and River Benue; bordered by states such as Kaduna (north-east), Plateau (east and south), Niger (west and north-west) and Kogi (southwest). The city shares border with Kaduna State from the North, Nasarawa

State from South-East, Kogi State by the South–West and Niger State on the West [26]. Currently, Abuja has a population estimated at 1,406,239 people [27].

Fig. 2: Map of Africa with an inset map of Nigeria showing the study area.

Abuja's location is central to other parts of Nigeria than its former Lagos. The central location of Abuja was chosen, to provide equal access to all [26]. Its central location and economic opportunities make it a hub for many people especially the unemployed.

2.2 Data Collection Techniques and Analysis

Prior to the questionnaire survey, a reconnaissance survey of the study area was carried out before embarking on the actual field work. This was carried out to test the viability of the proposed approach and to explore the study area and its environs, in order to obtain a clear picture of the problems.

For this study, the data was collected using multiple techniques. Socio-economic data was generated from questionnaire responses and spatial data such, as water points, geographical locations were collected. Participants were recruited through door-to-door techniques in four (4) areas namely: Apo Dutse, Orozo, Nwanlege and Kubwa with permission from the local heads of the communities. The process involved the administration of 200 questionnaires to participants on safe water provision in four Peri-urban areas in Abuja. The questionnaire procedure was carried out in a random sampling technique. The questionnaire was developed by establishing ideas, and questions were drawn from the literature review. The questionnaire consisted of two segments: the first segment entailed socio-economic information about the respondents as regards, gender, age, education, family size and income. The second segment consists of information on people's perception about water access issues was gathered. This method of data acquisition was employed, in order to collect primary data from the people. The data generated from the field survey has been classified to showcase water type (piped and borehole), cost of assessing water and water quality in the study area.

Quantitative data was analysed using descriptive statistics on Microsoft excel and SPSS software while the qualitative aspect was analysed using content analysis.

3. RESULTS AND DISCUSSION

3.1 Socio-economic findings

In the four study sites, a total number of 200 residents were administered questionnaires. As seen on Table 1; the number of residents in both Apo and Orozo were the same while Nwanlege and Kubwa varied with men taking the lead in both communities.

Table 1: Statistical Table of the Respondents by Sites

Gender	Apo	Orozo	Nwalenge	Kubwa
Male	25	25	30	26
Female	24	24	20	24
Rather not say	1	1	0	0
Total	**50**	**50**	**50**	**50**

3.2 Sources of Household Water

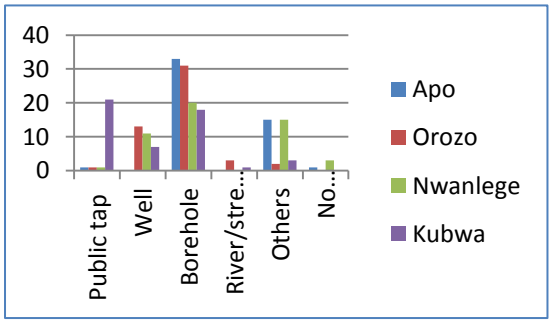

Fig. 3.1: Bar chart showing different sources of drinking water in the study areas.

The bar chart above provides information on the different drinking water sources cited by respondents of the four study sites. It shows the different sources of drinking water ranging from public tap, borehole, well, river. For the purpose of this study, "others" refers to as water sources from (vendors, water tankers). Apo Dutse and Orozo residents, rely mainly

on borehole water as their source of drinking water. Borehole water source has the highest frequency of 33 and 30 for Apo and Orozo. Nwanlege residents rely on borehole, well and other sources such as vendors and water tank as their sources of drinking water. While, Kubwa residents depend on mostly public tap with a frequency of 22, as well as bore hole with a frequency of 18 as their sources of drinking water.

As illustrated on the chart, there are some variations between the study sites as to where residents obtain water. These variations could be as a result of the differences in socio-demographic characteristics of residents [28].

3.3 Water Access

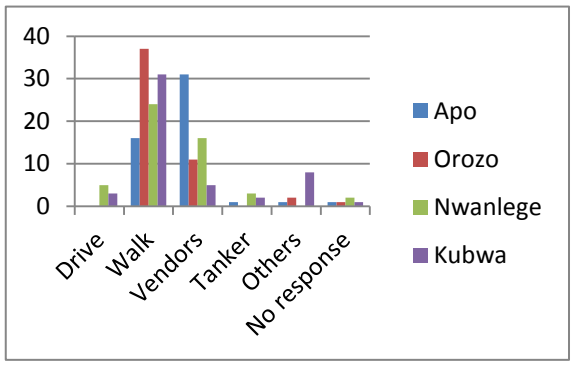

Fig. 3.2: Bar chart showing water access in other areas.

Fig 3.2 shows the result of water access as by respondents in all study sites. It shows the number of responses given for each category (Frequency) and Percentage (Percent) of respondents that chose the options. As indicated, residents of Apo Dutse area access water through vendors with a frequency of 31, while 16 have to walk to access water. Majority in Orozo, Nwanlege and Kubwa, as shown with a frequency of 37, 23 and 32 respectively, walk to access water from their homes.

3.4 Average Time for Collecting Water

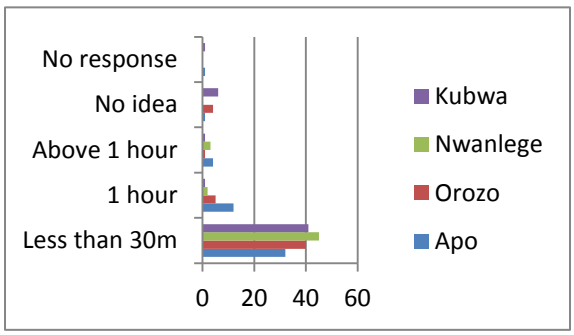

Fig. 3.3: Bar chart showing the average time spent to collect water in the study sites.

Figure 3.3, illustrates the average time spent by individuals for collecting water in each study site. As illustrated on the chart, it takes less than 30 minutes to collect water in most sites. For example, 45 and 40 people responded in Nwanlege and Orozo and according to them, it takes them less than 30 minutes. On the other hand, about 35 and 32 people responded to the having spent less than 30 minutes for collecting water in Kubwa and Apo Dutse environs. This could be because majority of the people in these areas rely on vendors that are readily available for their water needs. On the other hand, it takes an average of 1 hour for some people in Apo Dutse (12), Kubwa (6), Orozo (5) and Nwanlege (2); which could be due to the location of their houses from the sources of water. A few people responded to an average time of above 1 hour for the time used to collect water in the study sites.

Table 2: Statistical Table of the Cost of Water in the Study Sites

Response	Apo	Orozo	Nwanlege	Kubwa
Less than 500	3	23	15	11
501-N1000	6	21	4	15
N1001-N5000	21	6	26	20
N5001 and above	17	0	3	0
No response	3	0	2	4
Total	50	50	50	50

Table 2, presents information on the cost of water access as cited by respondents in all four sites. As shown on the table, it cost the residents of Apo Dutse between N5000 and above to get water. Apo Dutse has the highest response in this category with 21 and 17 people responding to the question. The high cost of purchasing water could be due to the location of Apo Dutse in the central part of Abuja, as well as heavy reliance on borehole water which is quite expensive. On the other hand, Orozo areas spend an average of N501–N5000 on water with a total response of 21, followed closely by Kubwa with 18 respondents.

According to [26], water service delivery consists of infrastructure financing and development, water system operations and system maintenance and management. Abuja, like many other developed cities, offers a monopolised drinking water delivery system to the public through the government (FCT,

Water Board). However, due to the high influx of migrants into the city, water demand has not been met. This explains why majority of the respondents had alternative sources of water.

3.5 Water Quality

The bar chart below, shows that majority of the people surveyed preferred the quality of water to its cost in all four areas (Nwanlege, Apo, Kubwa and Orozo). This finding indicates that people value their well-being more over cost, which is understandable because water is life and human health is connected with the quality of water consumed. [29] stated that when the environment is destroyed or damaged, social health problems among communities are unavoidable due to the relationship between water and sanitation/hygiene.

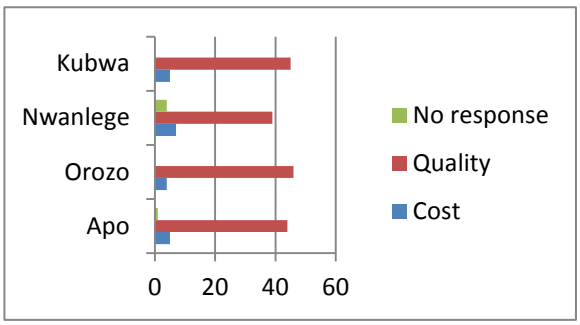

Fig. 3.4: Bar chart showing the residents preference between cost and quality of water in the different study sites

3.6 Water Access Challenges

Population Growth

Nigeria is known as the Giant of Africa due to its massive population of over 180 million people and one of the largest economy in Africa and the world. It is a nation that is endowed with both natural and human resources but unfortunately happens to be among the poorest nations in the world (20th), with a GDP of US$ 1.053 per capita [30]. The Nigerian Federal Government is responsible for the general governance of water resource management with stake holders and other tiers of government (state and local) [30]. Each tier of government is responsible for water supply and sanitation as its level. For example, the state government deals with urban areas while the local government deals with the rural water supply and sanitation [30]. Although, both the state and local government rely on the federal government for funding of any services which often a times causes delays and setbacks.

Deteriorating level of water infrastructures

Owing to Inadequate water access and poor sanitation practices, deteriorating state of water infrastructures, the prevalence of communicable diseases is also high which reduces economic productivity [26]. For example, the rise of diseases, such as the recent Ebola outbreak and other contagious haemorrhagic viral diseases, has called for drastic health protection measures to be implemented. Even though many laws, standards, guidelines, international treaties and conventions aimed at safeguarding man and the environment have been put into place, all have had limited impact in Nigeria [26].

Ineffective Government Policy

It is difficult to ignore the many environmental, political and socio-economic challenges that are associated with unsafe water provision [26]. In Nigeria, the majority of cities are still faced with contaminated water challenges as a result of weak environmental policies and people's nonchalant attitudes to environmental issues. Changes in government and leadership often affect the policies and regulations of previous governments, which halt developments, as well as climatic and hydrological changes that make water resource management a challenge. The government's policies continually change as their tenure or administration terminates, which leaves some projects unattended and uncompleted; whilst a new administration comes on-board with new policies and reforms which often create further problems and waste funds [26].

The structures of the Nigerian government and other factors such as political, economic, social, technological, legal and environmental (PESTEL) affect water resource management (Fig. 2) [30]. Most especially the political aspect of governance which is influenced deeply by corruption affects water service delivery, which in turn halts development [30]. Unrealistic plans and promises are set up in order to win people's electoral votes and once these agenda are achieved; these plans are abandoned at the detriment of human lives.

Poor Management

Despite the abundant freshwater resources that the country of Nigeria boasts; lack of appropriate Geospatial data is a key element in the poor management of water resources. In Nigeria, most governmental and non-governmental agencies acquire and store geographic data in analogue format which can be time consuming to access. Based on the aforementioned, the use of traditional methods for data storage limits the use and capabilities of GIS applications. Also, the lack of policies for data access and sharing makes water resource management

challenging. On the contrary, GIS applications in developed regions have eased the many issues of data acquisition, storage, processing and have enabled the dissemination of digital information for planning purposes [20].

4. RECOMMENDATIONS

Spatial & Temporal Data-Key for Water Resource Management

GIS has the capabilities to incorporate spatial and temporal data with other data to provide information for better water management. GIS is useful to water suppliers as it provides updated information and an inventory of water data such as: water quality, contamination and the location of water pipelines. It has been used for spatial data acquisition and integration using remote sensed data, i.e. GPS and field data for water resource management to replace conventional mapping systems with computer based systems [31].

Planning & Decision Making.

GIS could be a helpful decision and planning tool to water managers to equip them with information about how to integrate water information, climate change and Geographic Information within water management. GIS connects society through methods such as Public Participation GIS (PPGIS). GIS technology can be used as an assessment and application tool for water resource management to detect and map coastal area hazards, water hazards, in water quality detection, wetlands ecology, water pollution, flood mapping, irrigation engineering, farming, and to provide infrastructural information [32].

5. CONCLUSIONS

This study shows that:

Developing countries such as Nigeria need to embrace and implement effective systems that are sustainable. This is necessary, in order to meet the shortfall that countries like Nigeria could not achieve in the water sector of the Millennium Development Goals (MDGs). In order to meet the Sustainable Development Goals (SDGs), there is the need for proper planning to mitigate the targets that were not met in the MDGs.

Owing to the near lack of employment, infrastructure and other basic services in major cities and rural areas of Nigeria, the city of Abuja will continue to experience high influx of people; “thereby putting more pressure on the existing over stretched water supply” in the city and the adjoining satellite towns. It is important for the government to re-strategize its policies and implementation strategies; especially in the area of potable water delivery. These policies when implemented and managed effectively, will impact positively on other aspects of the health of people and reduce the time and sufferings associated with daily sources of potable water; thereby, putting more time into other productive ventures across the economy.

Also, developing countries such as Nigerian need to invest more in research to understand the problems, from grass roots to federal level, by engaging communities and private stakeholders in decision making. Geospatial technology when employed will aid to showcase water access and delivery challenges in their spatial location and facilitate efficient ways for effective water resource management through equitable allocation of water resources. Geospatial technology will also provide information that will enable decision makers to act on areas that are mostly affected by severe water pressures, which will enable proper management of the water sector. Nigeria, as a nation with the largest population in Africa, has an important role to play in water related issues; as an outbreak of disease there could have direct impact on the whole African region.

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REFERENCES

1. United Nations Environment Programme Annual Report, 2010. A Year in Review.

2 Yan, D., Yao, M., Ludwig, M., Kabat, P., Huang H., Hutjes, W.A.R., Werners, E. S., 2018. Exploring Future Water Shortage For Large River Basins under Different Water Allocation Stategies. Water Resource Manage ment32:3071-3086

3. Thakadu, T. O.,Ngwenya, N. B., Phaladze, A. N., Bolaane, B. 2018. Sanitation and Hygiene Practices among Primary School Learners in Ngamiland District, Bootswana 105, 224-230.

4. United States Environmental Protection Agency, 2016. Summaries of EPA Water Pollution Reporting Categories used in the ATTAINS Data System (No. EPA841-R-16-003), ATTAINS parent cause category summaries.

5 World Health Organization, 2017. Monitoring Health for the SDGs. World Health Organization; Geneva; [New York.

6 United Nations Educational and Scientific and Cultural Organization, 2015. Water for Women.

7 United Nations World Health Organization, 2012. The United Nations Water Annual Report 2012: Water Resource Management.

8. Gao, H., Bohn, J, T., Podest, E., Mcdonald, C, K., Lettenmaier, P. D., 2011. On the causes of the shrinking of Lake Chad. Environmental Research Letters 6, 034021 (7pp).

9. Martínez, J., 2009. The use of GIS and indicators to monitor intra-urban inequalities. A case study in Rosario, Argentina. Habitat International 33, 387–396.

10. Merem, E.C., Twumasi, T., Wesley, J., Isokpehi, P., Shenge, M., Fageir, S., Crisler, M., Romorno,C., Hines, A., Hirse, A., Ochai, S., Leggett, S., Nwagboso, E., 2017. Analyzing Water Management Issues Using GIS: The Case of Nigeria. Geosciences 7(1); 20-46.
11. Jarayathna, L., Rajapaksa, D., Managi, S., Athukorala, W., Torgler, B., Garcia-Valinas, A. M., Gifford, R., Wilson, C., 2017. A GIS based spatial decision support system for analysing residential water demand: A case study in Australia. Sustainable Cities and Society 32. 67-77.
12. Brown, P.G., Schmidt, J.J., 2010. Water ethics: foundational readings for students and professionals. Island Press, Washington, DC.
13. World Health Organization, UNICEF (Eds.). Progress on sanitation and drinking water. World Health Organization, Geneva, 2010.
14. Liu, J., Liu, Q., Yang, H., 2016. Assessing water scarcity by simultaneously considering environmental flow requirements, water quantity, and water quality. Ecological Indicators 60, 434–441.
15. Jaglin, S., The right to water versus cost recovery: participation, urban water supply and the poor in sub-Saharan Africa. Environment and Urbanization 14, pp. 231– 245, 2002.
16. Rondi, L., Sorlini, S., Collivignarelli, M., 2015. Sustainability of Water Safety Plans Developed in Sub-Saharan Africa. Sustainability 7, 11139–11159.
17. World Health Organization, UNICEF, 2015. Progress on sanitation and drinking-water: 2015 update and MDG assessment. World Health Organization; UNICEF, Geneva; [New York.
18. Koc, A.C., Ciner, F., Toprak, S., Selcuk, H., Aktan, B., 2010. The Geographical Information System (GIS) based water quality assessment of a drinking water distribution system in the Denizli City. Desalination and Water Treatment 19, 318–324.
19. Wilson, P. John, Fotheringham, S., A., 2008. The Handbook of Geographic Information Science.
20. Igboekwe, M.U., Akankpo, A.O., Application of Geographic Information System (GIS) in mapping groundwater quality in Uyo, Nigeria. International Journal of Geosciences 2, pp. 394–397, 2011.
21. Muhammad, M.A., Relevance of Geographic Information Systems (GIS) and Remote Sensing (RS) to Environmental Education: A panacea for sustainable development in Nigeria. Academic Journal of Interdisciplinary Studies, 2013.
22. Salman Hussain, Jasim Mahdi, A GIS Assessment of Water Quality in Euphrates River/Iraq 23, 2015.
23. Nwachukwu, M., Aslan, A., Nwachukwu, M., Application of Geographic Information (GIS) in sustainable ground water development, Imo River Basin Nigeria, 2013.
24. Brown, G., Kyttä, M., Key issues and research priorities for public participation GIS (PPGIS): A synthesis based on empirical research. Applied Geography 46, pp. 122–136, 2014.
25. Adeoye, A., 2006. Abuja Geographic Information Systems (AGIS) as a tool for Good Governance in Nigeria, in: Promoting Land Administration and Good Governance. Presented at the 5th FIG Regional Conference, Accra, Ghana.
26. Abubakar, I.R., Quality dimensions of public water services in Abuja, Nigeria. Utilities Policy 38, pp. 43–51, 2016.
27. National Population Commission, 2006. National Population Census. Federal Republic of Nigeria Official Gazette, 96 (2).
28. Ghavidelfar, S., Shamseldin, Y. Asaad., Melville, W. Bruce., 2018. Evaluating spatial and seasonal determinants of residential water demand across different housing types through data integration. International Water Resources Association.
29. Jimenez, A., Cortobius, M., Kjellen, M., 2014. Water, Sanitation and Hygiene and Indigenous Peoples: A review of the Literature. Water Internnational Journal.
30. Meldrum, L.A., 2019. Water Justice and its Dynamic Links to Water Resource Management, Water Security and Conflict in Nigeria. Global Journal of Engineering Sciences.
31. Mentis, D., Welsch, M., Nerini, F. F., Broad, O., Howells, M., Bazilian, M., Rogner, H. A GIS-based approach for electrification planning- A case study on Nigeria. Energy for Sustainable Development 29, 142-150.
32. Brown, G., Kyttä, M., 2014. Key issues and research priorities for public participation GIS (PPGIS): A synthesis based on empirical research. Applied Geography 46, 122–136.